Relating Weight Gain and Feed:Gain of Male and Female Broilers to Rearing Temperature[1]

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ABSTRACT The effects of environmental temperature on growth and feed:gain were studied in three trials each for male and female broilers. Chicks were reared in a common environment to 21 d of age. At 21 d, they were randomly allocated to 10 environmental chambers. Each chamber was maintained at a constant temperature; the chambers ranged from 12 to 30 C in two-degree increments. The dewpoint was maintained at 18 C, except that relative humidity was not permitted to exceed 82.9%. Body weight was determined at 21 d. Weight gain and feed:gain were determined at 28, 35, 42, and 49 d. The data were analyzed statistically, and regression equations were obtained for weight gain and feed:gain for each sex. Equations were based on body weight and temperature, and the body weight equations were plotted as grams gained per bird per day. Feed:gain increased with increasing weight. The temperature that resulted in the most favorable feed:gain decreased with increasing weight. These results support lower rearing temperatures for optimum growth and feed:gain by large broilers than those of other reports in the literature.

(*Key words*: temperature, weight, growth, feed:gain, broiler)

2001 Poultry Science 80:581–584

INTRODUCTION

Much research has been directed toward finding the optimum environmental temperatures for broiler production. The fact that the most favorable temperatures decrease with increasing age is well known (Charles, 1986). Data have also been reported that show the optimum temperatures for growth and feed:gain sometimes differ for male and female broilers (Hurwitz et al., 1980). Although there are many reports on the effect of environmental temperature on growth and feed:gain, most of the data are for specific periods of time. Such data are of limited usefulness to poultry growers who are making decisions about specific weight broilers. The most useful data to relate these production parameters to temperature are the reports by Reece and Lott (1982, 1983). Those data are over 15 yr old and were based on age rather than body weight. Genetic selection has resulted in continuous improvements in growth rate and feed:gain (Havenstein et al., 1994). More recent data, reported by May et al. (1998), have provided information for male broilers over a limited temperature range. As the broiler industry has matured in the United States, housing has improved with better insulation, ventilation, evaporative cooling, and heating systems. These improvements have been accompanied by increased expenditures for electricity and LP gas to control the environment.

Poultry growers contract with companies to grow broilers. The contracts that poultry companies pay growers are for the quantity of live broilers grown and provide incentives for better than average feed:gain. Feed is more expensive than any other input in the rearing of broilers. Profitability for growers depends upon providing facilities and management that balance input cost against return. Growers provide electricity, water, and gas for heating and cooling to improve the rearing environment. Informed decisions about profitability requires knowledge of the effect of environmental temperature on growth rate and feed:gain.

The objective of this research was to provide growth and feed:gain equations over a broad range of temperatures and body weights. The equations give quantitative estimates of the effects of changes in temperature on growth and feed:gain from 12 to 30 C for male and female broilers.

MATERIALS AND METHODS

Ross × Ross chicks were obtained from a commercial hatchery and reared on litter in six trials, three for males and three for females. Feed and water were provided ad libitum, and lighting was continuous. Corn-soybean diets were formulated to meet or exceed National Research

Received for publication July 24, 2000.

Accepted for publication December 29, 2000.

[1]Trade names in this article are used solely to provide specific information. Use of trade names does not constitute a guarantee or warranty by USDA and does not signify that the product is approved to the exclusion of other comparable products.

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TABLE 1. Temperatures and humidity for the 21- to 49-d period

Temperature (c)	Relative humidity (%)
12	81.9
14	82.1
16	82.4
18	82.6
20	82.9
22	78.1
24	69.2
26	61.4
28	54.6
30	48.6

Council (1994) requirements. The chicks were placed on fresh pine shavings in a controlled-environment house when they were received from the hatchery. The temperature was initially 31 C and was reduced to 29 C after 3 d. At 7 d, the temperature was changed to 27 C, and at 14 d, the temperature was changed to 24 C. All broilers were provided trough waterers throughout the study.

Broilers were moved to 10 environmental chambers (Reece and Deaton, 1969) at 21 d of age. They were also reared on litter in the chambers. The environmental chambers were used to maintain constant temperature and humidity conditions during the 21- to 49-d treatment period. The temperatures and humidities of the chambers are given in Table 1. At temperatures of 22 C and above, the dewpoint was 18 C. Below 22 C, the relative humidity was approximately 82%. Each chamber was 2.32 × 2.59 m and was stocked with 75 broilers. Each chamber had a 2.44-m trough waterer on one side of the chamber and two tube feeders with pans 35 cm in diameter. Weight gain and feed:gain of all broilers were determined at 28, 35, 42, and 49 d of age. The trials were replicated over time with three trials for each sex.

Statistical Analysis

The data were analyzed by PCSAS Release 6.02.[3] Regression analysis for response surfaces were used to explain body weight gain per day and feed:gain as a function of temperature and beginning weight. The response surface equation was then simplified to eliminate unnecessary terms.

RESULTS AND DISCUSSION

Body weight, weekly gain, and feed:gain for male broilers are given in Table 2, and the data for those parameters for female broilers are given in Table 3. The data show the expected increase in feed:gain with increasing weight for both sexes. The temperature that resulted in the optimum feed:gain decreased with increasing weight.

Equations were derived from the data to describe the effect of body weight and temperature on growth and feed:gain. They were as follows.

Male Gain

$$G = 98.838 + 4.2822X10^{-2}BW - 1.1662X10^{-5}BW^2 - 13.167T + 0.72569T^2 - 1.1155X10^{-2}T^3 + 2.3823X10^{-3}BWT - 9.3517X10^{-5}BWT^2 \quad (R^2 = 0.82).$$

Male Feed:Gain

$$FCR = -0.30582 + 1.8099X10^{-4}BW + 1.3633X10^{-7}BW^2 + 0.38552T - 1.9945X10^{-2}T^2 + 2.9056X10^{-4}T^3 - 6.9059X10^{-5}BWT + 2.45998X10^{-6}BWT^2 \quad (R^2 = 0.90).$$

Female Gain

$$G = 76.4125 + 3.9563X10^{-2}BW - 1.4336X10^{-5}BW^2 - 8.9587T + 0.48155T^2 - 6.9098X10^{-3}T^3 + 2.7052X10^{-3}BWT - 1.0498X10^{-4}BWT^2 \quad (R^2 = 0.92).$$

Female Feed:Gain

$$FCR = 2.1838 - 1.442X10^{-3}BW + 9.066X10^{-7}BW^2 - 1.787X10^{-10}BW^3 - 2.9808X10^{-2}T + 8.2737X10^{-3}T^2 - 2.2672X10^{-4}T^3 + 5.7681X10^{-5}BWT + 2.1995X10^{-8}BW^2T - 1.0728X10^{-5}BWT^2 + 2.6222X10^{-7}BWT^3 \quad (R^2 = 0.95).$$

TABLE 2. The effect of environmental temperatures on weight gain and feed:gain (F:G) of male broilers

Temperature (C)	Beginning weight (g)	21 to 28 d		28 to 35 d		35 to 42 d		42 to 49 d		Ending weight (g)
		Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	
12	841.7	515.6	1.82	623.6	1.87	681.9	2.02	672.9	2.29	3,335.7
14	837.9	555.0	1.73	660.0	1.88	652.8	2.11	653.0	2.28	3,358.7
16	843.3	535.0	1.76	626.5	1.87	672.8	2.02	702.9	2.15	3,380.5
18	840.9	558.1	1.71	696.0	1.74	703.3	1.98	608.7	2.45	3,407.0
20	842.9	577.7	1.66	641.4	1.80	702.6	1.95	612.6	2.42	3,377.2
22	844.9	566.8	1.66	614.6	1.86	667.7	2.03	572.8	2.54	3,266.8
24	841.7	564.8	1.65	648.0	1.79	620.5	2.23	557.4	2.41	3,209.2
26	842.0	595.6	1.59	629.0	1.83	620.0	2.08	520.9	2.62	3,228.2
28	846.6	570.6	1.63	599.0	1.79	546.2	2.18	439.6	2.77	3,002.0
30	845.0	535.0	1.66	492.7	2.07	502.7	2.24	339.4	3.28	2,714.8

TABLE 3. The effect of environmental temperatures on weight gain and feed:gain (F:G) of female broilers

Temperature (C)	Beginning weight (g)	21 to 28 d		28 to 35 d		35 to 42 d		42 to 49 d		Ending Weight (g)
		Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	Gain (g)	F:G (g:g)	
12	813.6	494.6	1.79	555.7	1.96	590.2	2.21	533.3	2.78	2,987.4
14	802.9	491.2	1.83	557.8	1.88	562.2	2.23	523.2	2.63	2,937.3
16	804.1	508.6	1.74	545.7	1.91	583.9	2.18	518.8	2.63	2,961.1
18	805.1	521.8	1.69	573.9	1.92	560.8	2.22	499.2	2.67	2,960.8
20	810.7	510.6	1.76	567.9	1.88	575.5	2.20	486.7	2.66	2,951.4
22	789.9	502.2	1.72	555.2	1.85	536.0	2.27	471.7	2.70	2,855.0
24	795.0	516.3	1.67	549.6	1.86	494.9	2.33	428.5	2.84	2,784.3
26	795.7	503.8	1.75	505.3	1.91	468.7	2.38	406.6	2.89	2,700.6
28	812.7	481.7	1.77	484.0	1.96	437.3	2.47	323.8	3.37	2,590.8
30	798.0	467.3	1.77	458.3	1.98	335.1	2.77	304.1	3.31	2,362.8

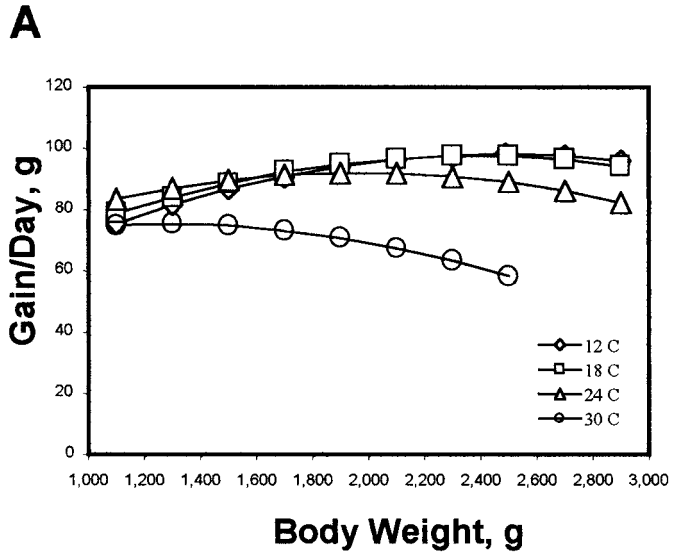

FIGURE 1. The effect of environmental temperature on daily body weight gain for male (A) and female (B) broilers. The values are derived from regression analysis of data from three trials.

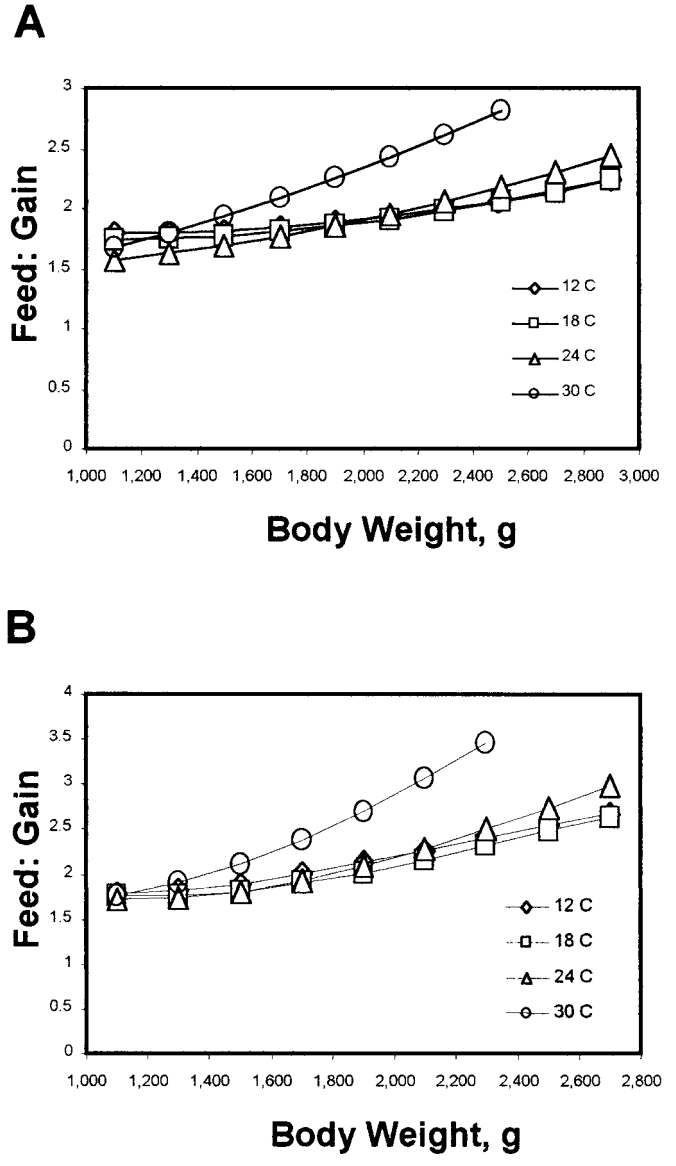

FIGURE 2. The effect of environmental temperature on feed:gain for male (A) and female (B) broilers. The values are derived from regression analysis of data from three trials.

where G = gain per day (g); BW = body weight (g); T = environmental temperature, (C); and FCR = feed:gain in g of feed consumed per g of BW gain. The equations were used to plot curves for weight gain (Figure 1) and feed:gain (Figure 2). Body weights were depressed by high temperatures, which resulted in a variable range over which the equations are valid. One must be careful not to extend the range for which the equations are used beyond the range of 12 to 30 C or the body weights beyond the ranges for each sex given in Table 2.

The weight gain equation predicts the maximum rate of gain for male broilers to be 98.3 g per day at 12 C for males weighing 2.48 kg. The maximum rate of gain for females was 82.8 g per day for 1.98 kg females at 14 C. The feed:gain equations predict the optimum temperature for 1.5 kg males and females to be 24 C and 21 C, respectively. At 2.5 kg, the optimum is 19 C for males and females. The optimum temperature for males weighing 3.0 kg was 12 C for weight gain and 16 C for feed:gain.

These data differ from previous literature for the effect of temperature on growth and feed:gain for broilers. Many factors must be considered in understanding the difference. These results are for rapidly growing broilers grown on litter. Cheng et al. (1997) housed male broilers on wire to 7 wk, and the maximum weight attained was 2.6 kg. Their conclusion was that the optimum feed conversion was obtained at 26.6 C. The results were for 3 to 7 wk of age. In this research, the optimum feed:gain for 0.85 kg males was at 27 C, but at 2.6 kg, the optimum temperature was 18 C. Leenstra and Cahaner (1991) reported better feed efficiency at normal rather than at low temperatures. The low temperatures ranged from 15 to 20 C, and the normal temperatures were from 20 to 26 C. Body weights were a maximum of 2.3 kg, and the period covered was from 4 to 6 wk.

Sex, body weight, and growth rate are factors in the effect of temperature on feed:gain and weight gain. Extrapolation of the results of this research to a commercial setting is difficult because the research pens were small, and the broilers were always close to feed and water. Finisher pens were cleaned and provided with new litter between trials. Pen temperatures were constant and had little air movement.

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